Introduction to the INEEL Report

The Idaho National Engineering and Environmental Laboratory (INEEL) was originally an isolated area whose specific purpose was the testing of various reactor concepts. The space available at the INEEL permitted wide spacing between reactor sites so that an incident at one site would not adversely affect activities at another site. In support of the reactor development activities the Idaho Chemical Processing Plant (ICPP) was built originally to recover the precious and rare enriched uranium from the spent fuel used in the reactors at the INEEL. Thus, the ICPP became a "source" of recycled uranium in the DOE complex.

In the early 1980s an existing facility at Test Area North was retro fitted to manufacture depleted uranium tank armor. The hanger that was built for the nuclear aircraft program houses this facility. This facility became the only "user" of recycled uranium at the INEEL.

Thus, the INEEL has two missions with respect to recycled uranium, one as a "source" and the other as a "user." Because the problems and the discussions are so totally different, this report will detail each as a separate report.

The Specific Manufacturing Capability part falls clearly into a de minimis category. They have only worked with one lot of material of which they still have some. As the result, samples that were recently analyzed showed that they had only traces of the elements of interest. Because there is no process which concentrates any of the minor constituents in their uranium they do not expect to have any problems with either handling their material or sending the scrap back to the fabricator.

The ICPP recycled uranium that had been irradiated in a reactor. The spent fuel material was processed in remote cells and using remoted equipment. There was little opportunity to be exposed to the fuel or to the product. Most of the ICPP product was sent to Y-12 where it was purified again before being made into metal for fabrication into driver fuel for the Savannah River production reactors.

The ICPP processed approximately 30 metric tons of high enriched uranium product either as uranyl nitrate in solution or as uranium trioxide powder. The SMC facility used 6,800 metric tons of high quality depleted, uranium metal. Neither quantity is large compared to the balance of the complex.

1.0 IDAHO NATIONAL ENGINEERING AND ENVIRONMENTAL LABORATORY RECYCLED URANIUM MASS BALANCE PROJECT

1.1 Project Overview

The Idaho National Engineering and Environmental Laboratory (INEEL) was a source of recycled uranium recovered from spent fuel at the Idaho Chemical Processing Plant (ICPP) and was a receiver of recycled uranium at the Special Manufacturing Capability (SMC). Spent nuclear fuel from DOE-owned research and naval propulsion reactors was sent to the ICPP where it was dissolved, the uranium separated from the cladding and the fission products, and the uranium product shipped to other DOE-complex sites. The recycled uranium used at the SMC facility was fabricated into special shapes for their customer.

Because recycled uranium was implicated as a source of radiation dose to workers at the gaseous diffusion plants and associated linked plants in the DOE-complex, the uranium mass balance project was commissioned to identify other areas where recycled uranium could have caused dose to workers without their knowledge. The project is under the auspices of the Office of Nuclear Safety (EH-3) and chartered with reviewing the characteristics and flow of recycled uranium throughout the DOE Complex. This report specifically addresses the uranium mass balance for the INEEL.

The Bechtel BWXT Idaho Company (BBWI), under prime contract to DOE, was directed to prepare the INEEL site report for inclusion in the overall mass balance project report. A team consisting of six current contractor employees with a cumulative experience of 175 years at the ICPP was organized to research records of the activities and operations used with recycled uranium. Activities at ICPP were associated only with recycling uranium from spent fuel. By definition, the "recycled uranium" includes only the uranium after it has been separated from the fission products and concentrated to two hundred or more grams per liter or converted to uranium trioxide.

Data sources were researched to determine the quantity and transaction date of all the uranium shipped from ICPP, and attempts to corroborate shipments were made with the principal recycled uranium receivers. Of particular concern were the years from 1953 to 1966, when the shipping forms were missing. A spot check of the receiver's copy at Y-12 indicated that the figures on a cumulative shipping compilation were accurate.

Most analytical data files were sent to a records repository where they were destroyed after five-years of storage. The only analytical data remaining is a limited amount of data in computer files in the analytical department and some late 1980s data that is still in the repository because of a moratorium on records destruction. No technetium measurements were ever made because technetium contamination was not a significant problem in ICPP product.

In order to compensate for the lack of data, ORIGEN2 calculations were made for the different worst case fuels that were typical of fuels processed at ICPP. These fuels were for high-burnup, aluminum-clad MTR fuel; low-burnup, fast-reactor EBR-II fuel, and a high-burnup, zirconium-clad fuel. The results of the calculations were checked against uranium, neptunium, and plutonium isotopic analytical data and were found to agree relatively well with actual analytical data for dissolver product composite samples. As such, the ORIGEN2 calculations gave the radionuclide composition for the dissolver product.

Many of the run reports included decontamination factors that measured the decontamination of alpha, beta, and gamma radionuclides through the extraction cycles. From that data, the alpha, beta, and gamma emitting radionuclides can be determined in the final product.

Some data also existed on the alpha ratio, which was used as a measure of the alpha purity of the uranium product. Knowing how the alpha ratio was defined, allowed analysts to estimate the amount of transuranic elements shipped with the product. Thus, an accurate estimate could be made of the amount of contaminants present in the recycled uranium product. These estimates bound the amounts of isotopes in recycled uranium that the ICPP workers were exposed to when handling the product. It is interesting to note that when a calculation was made to determine the relative risk for various radionuclides in the product, those that had the highest risks were from some of the uranium isotopes. Based on current estimates, ICPP workers had the greatest potential for dose during:

1) Packaging the product.
2) Maintenance activities associated with repairs to the denitrator or the liquid handling system.
3) Analysis of final product samples.
4) Radiation monitoring of these activities.

Since the plant started up, there have been many cases of worker dose including some to recycled uranium. There have been cases of internal dose that occurred during extraction and dissolution operations.

1.2 Purpose and Scope

The purpose of this project is to estimate the historical mass flows and characteristics of the recycled uranium produced at ICPP and shipped to other sites in the DOE complex. The information from this project will enable DOE to assess the potential for worker dose and environmental contamination from recycled uranium. Of particular interest in the ICPP product were isotopes of plutonium and neptunium and technetium-99. Uranium-236 is also of interest. This project focuses on:

1) Identifying the mass flow of DOE recycled uranium from the startup of fuel reprocessing at ICPP in February 1953 until March 31, 1999. This includes the sites where the recycled uranium was shipped. The ICPP shipped concentrated uranyl nitrate solution in nitric acid from 1953 until 1971. After 1971, uranium was shipped as solid, granular, uranium trioxide.
2) Identifying the major facilities where uranium was processed, and resulted in concentration of the fission products and the actinides. The streams from these processes are characterized to permit an assessment of worker or public health and safety issues.
3) Performing a site mass balance to the degree that existing mass and analytical data exists.

Items that are specifically excluded are:

1) Radioactive sources and standards. These items are typically sealed or are used as laboratory reagents. Their mass is accounted for through either the source control program or the nuclear materials control and accountability program. Their use is controlled to assure worker safety and, therefore, is not considered relevant to this study.
2) Uranium containing streams upstream of the liquid product evaporator. The exposure risks from material upstream is significantly higher than is found in recycled uranium. Because of the higher risk, this material is processed in heavily shielded cells using remote processing technology. Because this material is rarely accessible to workers and, when accessible is under strict control to minimize doses, all material and waste streams upstream of the product evaporator are outside the scope of this study. The uranium was not "recycled uranium" until it was ready to ship from ICPP.

1.3 Project Implementation Strategies

The project goals are as follows:

1) Identify the mass flow of recycled uranium from plant startup in 1953 until March 31, 1999 including the destination for recycled uranium shipments.
2) Identify the characteristics and contaminants in ICPP produced uranium product. Of particular interest are isotopes of uranium, plutonium, neptunium-237 and technetium-99.
3) Identify locations where potential exposure to hazardous contaminants in recycled uranium can occur at the ICPP.

The strategy for accomplishing the mass balance project at ICPP is as follows:

1) Utilize existing DOE and Bechtel BWXT LLC protocols, procedures, and controls.
2) Obtain and utilize existing staff specialists and support personnel.
3) Establish a structured approach to meeting the project goals including the use of key assumptions.
4) Ensure effective communication of progress, issues, and problem resolution through regular meetings with project personnel.
5) Coordinate with other sites and share results.

2.0 SITE HISTORICAL OVERVIEW

2.1 The ICPP is located near the center of the 900 square mile INEEL which was formerly the National Reactor Testing Station (NRTS). The plant occupies approximately one square mile near the test reactors in an area that had formerly been used by the Navy for test firing large guns following relining of the barrels. The current facility/layout is shown in Figure 1.

2.2 Key Uranium Processing Facilities

The ICPP corner stone was laid in 1951. The Atomic Energy Commission (AEC) contractor during construction was the American Cyanamid Corporation. The construction contractor was the Blaw-Knox Company. The facility was designed by personnel at the Oak Ridge Laboratory Facility. In February of 1953 the first fuel (a slug from a Hanford production reactor) was charged to the dissolver. The dissolver product was purified using three cycles of methyl isobutyl ketone (hexone) extraction in packed columns. The acidic first cycle waste was stored in a cooled, 300,000-gallon, stainless steel tank located in a concrete vault. The acidic second and third cycle waste was stored in a second 300,000-gallon, stainless steel tank located in a separate concrete vault. The product from this processing campaign was sent to the Y-12 facility at Oak Ridge to determine whether the product met the acceptance criteria. It was subsequently accepted, and the plant began processing fuel. The plant processed fuel from that initial campaign in 1953 until 1992 when fuel reprocessing was discontinued by a secretarial edict from then DOE Secretary James Watson. A clean-out campaign was completed in 1996 and the product from that campaign,which only recovered uranium from solutions in storage in the plant, is still in storage at ICPP.

The historical development of the uranium recovery process is shown in Figure 2.